CHAPTER III

PRIMARY PRODUCTIVITY
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3.1 INTRODUCTION

Primary production is the production of organic compounds from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis. All life on earth is directly or indirectly reliant on primary production. The organisms responsible for primary production are known as primary producers or autotrophs, and form the base of the food chain. In terrestrial ecoregions, these are mainly plants, while in aquatic eco-regions algae are primarily responsible. Primary production is distinguished as either net or gross, the former accounting for losses to processes such as cellular respiration, the latter not. Primary production is the production of chemical energy in organic compounds by living organisms. The main source of this energy is sunlight but a minute fraction of primary production is driven by lithotrophic organisms using the chemical energy of inorganic molecules.

GPP and NPP

Gross primary production (GPP) is the rate at which an ecosystem’s producers capture and store a given amount of chemical energy as biomass in a given length of time. Some fraction of this fixed energy is used by primary producers for cellular respiration and maintenance of existing tissues. The remaining fixed energy is referred to as net primary production (NPP).

\[ \text{NPP} = \text{GPP} - \text{respiration} \]

Net primary production is the rate at which all the plants in an ecosystem produce net useful chemical energy; it is equal to the difference between the rate at which the plants in an ecosystem produce useful chemical energy (GPP) and the rate at which they use some of that energy through cellular respiration. Some net primary production goes toward growth and reproduction of primary producers, while some is consumed by herbivores.
Both gross and net primary production are in units of mass / area / time. In terrestrial ecosystems, mass of carbon per unit area per day (gC/m²/day) is most often used as the unit of measurement.

Primary productivity is the rate at which the sun’s radiant energy is stored by photosynthetic activity of producer organisms in the form of organic substances which can be used as food material. The primary productivity is thus the basic of whole metabolic cycle in nature aquatic ecosystems, the remainder is consumption and decay.

Measurement of primary productivity gives information about the photosynthetic production of organic matter in area per unit time and the functional aspects of ecosystem (Odum, 1971). It is also concerned with the capacity of the system to utilize external energy, with subsequent transfer to higher system levels (Vollenweider, 1974). It also gives an idea about the exact nature of the ecosystem, its trophic level and the availability of energy for secondary producers (Clarke, 1954).

Primary productivity of an aquatic system also gives details about the amount of energy required to support the biological activity of the system. The role of primary production in the tropics is high due to sunshine and temperature. The primary productivity is controlled by different factors like alkalinity, pH, temperature, light and nutrients (Talling, 1971; Magard et al., 1979; Richardson et al., 1983).

The present study is made to elucidate the primary productivity (GPP and NPP) in Poovar estuary at three different stations during October 2004 to September 2005.

3.2 REVIEW OF LITERATURE

The limiting factors for primary production in West Coast Flors estuary was studied by Putnam (1966). The primary productivity of the Danish Wadden Sea was studied by Postma and Rommets (1970). Dehadrai (1970a), Dehadrai and Bhargava (1972), Bhattachir. et al. (1976) and Bhargava et al. (1977) have analysed the primary productivity of Mandovi and Zuari estuaries of Goa. The rate of primary production in Veli lake was investigated by Gopinathan (1975). Primary productivity of Porto Novo
waters was studied by Ramadhas (1977). Devassy (1983) studied the plankton ecology of some estuarine and marine regions of West coast of India.

Nair et al. (1983, 1984) studied the productivity of Ashtamudi and Kadinamkulam backwaters. The primary productivity of Muthupet estuary was investigated by Balusamy et al. (1987). Shibu (1991) studied the primary production in Kadinamkulam estuary. The primary productivity of Kadinamkulam estuary was also studied by Bijoy Nandan and Azis (1996). Iriarte et al. (1997) studied the primary productivity in shallow temperature estuary. Prema (2000) studied the primary productivity of Rajakkamangalam estuary. The primary productivity studies of Manakudy estuary was carried out by Arumugam (2002). The productivity in marine and fresh water ecosystems in Blackwell, Oxford, (UK) was studied by Marra (2002). The primary production studies of Rajakkamangalam and Manakudy estuaries were done by Maria Swarna Laila Bai (2005).

3.3 MATERIALS AND METHODS

Light and dark bottle technique (Gaarder and Gran, 1927) was used for the determination of primary productivity. The dissolved oxygen was estimated using modified Winkler’s method (Strickland and Parsons, 1976). The light and dark bottles were immersed in the water for three hours. After this, the oxygen content of the dark and light bottles were calculated by using the same method. The oxygen value thus obtained was in mg/Litre. This value was converted to carbon value by multiplying by the constant (respiratory quotient) 0.375.

\[
\text{GPP} = \frac{D_l - D_d}{h} \times 0.375 \text{ g C/m}^2/\text{day}
\]

\[
\text{NPP} = \frac{D_l - D_i}{h} \times 0.375 \text{ g C/m}^2/\text{day}
\]

DI = Dissolved O₂ content in the initial bottle (mg/L)
Dl = dissolved O₂ content in the light bottle (mg/L)
Dd = Dissolved O₂ content in the dark bottle (mg/L)
h = Time duration (in hour)
3.3.1 Statistical analysis

The data obtained in this study were subjected to the following statistical analysis (Zar, 1974) using SPSS package.

(i) Mean and Standard Deviation

(ii) Two-way Analysis of Variance (ANOVA).

3.4 RESULTS AND DISCUSSION

The monthly variations in gross and net primary productivity of the study area during the study period are given in Table 48.

The Monthly variation of gross and net primary productivity in water samples of Poovar estuary during the study period are presented in Figures 30 – 32.

3.4.1 Gross primary productivity

(i) Variations in GPP (gC/m$^2$/day)

The gross primary productivity (GPP) values ranged from 0.321 gC/m$^2$/day to 5.264 gC/m$^2$/day. The highest value was recorded in May at Station III and lowest value was recorded in January at Station I.

Maximum gross primary productivity value was recorded during pre monsoon season at Station III (4.277 gC/m$^2$/day) and minimum gross primary productivity value was recorded during post monsoon season at Station I (0.856 gC/m$^2$/day).

Statistical Analysis

The two-way ANOVA test for the data on GPP as a function of stations and seasons were statistically significant for GPP, $F = 37.0406$ and 25.6350; $P < 0.05$ (Table 49).
3.4.2 Net primary productivity

(i) Variations in NPP (gC/m$^2$/day)

The monthly data on net primary productivity (NPP) in the three stations revealed that net primary productivity values ranged from 0.147 gC/m$^2$/day to 4.428 gC/m$^2$/day. The maximum net primary productivity value was recorded in March at station III and minimum value was recorded in December at station II.

Net primary productivity was maximum during pre monsoon season at Station III (3.509 gC/m$^2$/day) and minimum during post monsoon season at Station II (0.642 gC/m$^2$/day).

Statistical Analysis

The two-way ANOVA test for the data on NPP as a function of stations and seasons were statistically significant for NPP F = 22.2508 and 12.6087; P < 0.05 (Table 50).

The GPP was maximum during pre monsoon season followed by monsoon and post monsoon seasons. The NPP was maximum during the month of March and minimum in December. In the present study, highest gross and net primary productivity values were obtained on pre monsoon season. Agarwal et al. (1995) also reported a positive relation between primary productivity and temperature in Sagar lake.

Purushothaman and Bhatnagar (1976) recorded a positive relation of primary productivity with temperature and salinity in Porto Novo waters. Thangaraj et al. (1979) noticed high gross primary productivity during Summer. In the present study there was a direct correlation between temperature and production which is in agreement with Thomas et al. (1979) and Agarwal (1980). This may be due to the increased nutrient concentrations and warmer temperatures of the tanks and reservoir results in higher algal population (Patra et al., 1984).

The reduced primary productivity in post monsoon season was due to low illumination. Agarwal (1980) and Thomas et al. (1979) noticed that the weather
conditions alter the productivity in aquatic ecosystem. The low values of gross and net primary productivity in post monsoon season were due to much proliferation of water hyacinth and nutrient sink and its utilization by the macrophytes (Kolekar and Singh, 1999).

A negative relation of primary productivity with pH was reported by Agarwal et al. (1995) in the military engineering lake. The present study reveals a negative relation between primary productivity and pH. Agarwal et al. (1995) reported a positive relation between primary productivity and nitrite in Sagar lake which is in agreement with the present investigation. A negative relation was also obtained between primary production and salinity.

The effect of pollutants from the neighbouring resorts and the accumulation of pollutants might be the reason for less production. The study shows that the primary productivity values are also influenced by other environmental parameters like terrestrial and man made changes in the adjacent lands in the estuary. High rates of production occur in the estuary when physico-chemical factors are favourable (Maria Swarna Laila Bai (2005)). However, the rate of primary productivity is affected by anthropogenic activities, industrial effluents and sewage from the neighbouring resorts.

From the present study it was clear that the maximum production takes place at high temperature, high nitrite content with low pH and low salinity.
Table 48. Monthly variation in Primary productivity (gC/m²/day) recorded at different stations of Poovar estuary

<table>
<thead>
<tr>
<th>Station</th>
<th>Samples</th>
<th>Post monsoon</th>
<th>Pre monsoon</th>
<th>Monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Oct</td>
<td>Nov</td>
<td>Dec</td>
</tr>
<tr>
<td>I</td>
<td>GPP</td>
<td>1.675</td>
<td>0.947</td>
<td>0.481</td>
</tr>
<tr>
<td></td>
<td>NPP</td>
<td>1.324</td>
<td>1.759</td>
<td>0.362</td>
</tr>
<tr>
<td>II</td>
<td>GPP</td>
<td>0.412</td>
<td>2.041</td>
<td>0.824</td>
</tr>
<tr>
<td></td>
<td>NPP</td>
<td>0.346</td>
<td>1.652</td>
<td>0.147</td>
</tr>
<tr>
<td>III</td>
<td>GPP</td>
<td>3.203</td>
<td>2.901</td>
<td>2.245</td>
</tr>
<tr>
<td></td>
<td>NPP</td>
<td>2.184</td>
<td>2.361</td>
<td>1.740</td>
</tr>
</tbody>
</table>
Table : 49. Two-way analysis of variance for the data on the gross primary productivity

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station</td>
<td>6.063016</td>
<td>2</td>
<td>3.031508</td>
<td>37.04068</td>
<td>0.002624</td>
<td>6.944276</td>
</tr>
<tr>
<td>Season</td>
<td>4.196089</td>
<td>2</td>
<td>2.098044</td>
<td>25.63509</td>
<td>0.005238</td>
<td>6.944276</td>
</tr>
<tr>
<td>Error</td>
<td>0.327371</td>
<td>4</td>
<td>0.081843</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>10.58648</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table : 50. Two-way analysis of variance for the data on the net primary productivity

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station</td>
<td>4.779962</td>
<td>2</td>
<td>2.389981</td>
<td>22.25081</td>
<td>0.006802</td>
<td>6.944276</td>
</tr>
<tr>
<td>Season</td>
<td>2.708625</td>
<td>2</td>
<td>1.354313</td>
<td>12.6087</td>
<td>0.018743</td>
<td>6.944276</td>
</tr>
<tr>
<td>Error</td>
<td>0.429644</td>
<td>4</td>
<td>0.107411</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>7.918231</td>
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</table>
Fig. 30. Monthly variation of primary productivity (gCm²/day) in water samples of Poovar estuary Station I

Station II

Figure 31

Station III

Figure 32
CHAPTER IV

SEDIMENT CHARACTERISTICS